Measured in this way, the productivity offset includes the effect of any growth in minutes of use per line ("g" in the balanced 50/50 formula adopted by the Commission in the common line basket) because the LEC's measured TFP growth uses actual growth of both minutes and lines as the measure of output. Also, measured directly, LEC TFP uses an estimate of capital input which more accurately reflects economic asset lives rather than the artificial accounting asset lives which are embodied in the LEC data used to estimate the productivity offset in the indirect method employed by the Commission in 1990. Most importantly, we also observe that the productivity offset should be stable over a long period of time, and the price cap review should not be used to true up the productivity offset because of successes or failures of the regulated firms under the plan.

The Notice of Proposed Rulemaking (NPRM) sought comment as to whether the Commission should adopt a mechanism which would adjust the plan to reflect changes in interest rates or whether a one-time change in the LEC's price cap index should be required.[1] We examine these questions and find that the plan as originally articulated properly adjusts prices to reflect changes in interest rates and that there is no basis for a one-time change of the price cap index. No special adjustment for changes in interest rates is required because changes in interest rates represent changes in the input prices that affect every industry in the U.S. While changes in capital, labor or raw materials prices may affect the costs of different industries differently, depending on the mix of inputs used, we show that differences in input price growth rates are implicitly part of the productivity offset in the plan. Thus interest rate changes--as well as changes in other

[1]NPRM, CC Docket No. 94-1, Released February 16, 1994, Paragraph 46. .

input prices--are accounted for through (i) the measure of U.S. inflation (GNP-PI) and through the productivity offset which accounts for any differences between U.S. and industry input prices. The price cap-regulated firm thus does not automatically benefit when input prices fall; rather, it benefits only to the extent that it can adapt its inputs to the change in prices so that its costs fall relative to costs of other firms in the economy.

In theory, the purpose of the price cap review is to ensure that there are no gross errors in the components of the formula as established in 1990. Our assessment of the economic performance of the components of the formula to date is that there is no clear need to dramatically change any of its parameters.

ECONOMIC PERFORMANCE OF THE LEC PRICE CAP PLAN

The stated purpose of the Commission's review is to conduct a comprehensive examination of the effects of LEC price cap regulation. The Commission invited parties to submit data, analysis and comments regarding ways to improve the current plan. Specifically included among the issues were (i) an examination of the need to change the value of the productivity offset (X) and (ii) whether to make a one-time adjustment to the LEC price cap index or to adopt a mechanism for adjusting the plan to reflect changes in interest rates. In this report, we examine if there is a need to change the value of X and to adjust the price cap index for possible changes in interest rates.

I. THE ECONOMIC STRUCTURE OF PRICE CAP REGULATION

To evaluate the success of an alternative form of regulation, we must have a clear set of criteria that a regulatory plan should meet. Our starting point is the view that (with few exceptions) the competitive process leads to good economic outcomes: just and reasonable prices, suitable levels of service quality, an appropriate return on investment, an efficient use of scarce resources, the proper rate of technical progress, and an adequate incentive to implement and market new products and services. Thus, regulation should foster a competitive outcome in those markets where competition has yet to develop.

To refine the objectives further, a minimal theoretical objective is economic efficiency, i.e., that regulation should emulate competition in producing the most valued mix of goods and services given the limitations imposed by the scarce resources of the economy.[2] Economists distinguish between technical efficiency and allocative efficiency. Technical (or first-order) efficiency means that goods and services are produced at the lowest possible cost. Allocative (or second-order) efficiency means that prices are set so that consumption decisions are based on the true incremental cost of service and consumers thus exchange goods and services at the same rates that it costs society to produce them. The terms "first-order" and "second-order" efficiency refer to the likely magnitude of efficiency losses: technical inefficiency affects all output produced at excessive costs while allocative inefficiency affects only output at the margin, inappropriately stimulated or repressed by prices that differ from marginal cost.

In theory, rate of return (RoR) regulation sets prices equal to realized costs, so that allocative (second-order) efficiency is satisfied. This view of theoretical RoR regulation is a bit too simple for several reasons: (i) RoR regulation sets prices to recover embedded accounting costs, not forward-looking economic costs, and (ii) for a multiproduct firm, RoR sets aggregate prices equal to aggregate (embedded) costs, so that prices need not equal realized costs for each service. In practice, RoR regulation was in place while specific deviations from cost were imposed on numerous services (due, for example, to

[2]A measure of economic efficiency is the sum of (i) consumer surplus (the difference between what consumers actually pay for their goods and services and what they would be willing to pay) and (ii) producer surplus (the difference between what producers sell their goods and services for and the cost of producing those goods and services). Since the amount consumers actually pay is the same as what producers receive in revenue, this measure is really the difference between what consumers would be willing to pay for goods and services and the cost of producing them.

universal service, carrier of last resort, and readiness to serve obligations). In addition, the firm is given no incentive (in theory) to ensure that realized costs are minimum costs, so that allocative efficiency, if achieved, is achieved at a sacrifice of technical efficiency.[3]

Price cap regulation, in contrast, decouples (i) prices from observed costs and (ii) profits from investment so that the regulated firm has the same incentive to pursue technical (first-order) efficiency as an unregulated firm. The potential risk in decoupling prices from observed costs is that technical efficiency may be achieved at a sacrifice of allocative efficiency: over time, prices may begin to move away from costs.

Mitigating these concerns in the LEC price cap plan is the annual adjustment to the price cap, designed to correct the price cap for cost changes over time in a way that does not reduce incentives to minimize production costs. The annual adjustment to the price cap is carefully constructed to avoid compromising the incentive properties of the plan. In addition, the plan allows for periodic performance reviews which, if carefully conducted, can also be used to balance the achievement of technical and allocative efficiency. If misused, however, the results of a periodic performance review would significantly dilute any improvement in incentives the Commission intended with the adoption of the plan. Adjusting prices or the productivity offset for unanticipated successes or failures under the plan would perversely reward failure and punish success. In addition, a review period of four years is barely sufficient time to observe the effects of

[3]Of course, actual regulation differs from theoretical regulation, and such features of regulatory practice as regulatory lag and prudence audits diminish somewhat the incentive problems of traditional regulation.

improved incentives on the long-run behavior of the regulated company, and measurement of such changes would be inherently inaccurate.[4]

A pure price cap plan with annual adjustments to the price cap index sets a balance between the objectives of technical and allocative efficiency. Technical efficiency is encouraged because the firm keeps what it earns[5]. The linkages between earnings and investment and between prices and costs are effectively broken. Allocative efficiency is fostered through the annual price cap adjustment and the prudent conduct of periodic reviews.

A. The Logic of the Price Cap Adjustment Formula

The heart of the LEC price cap plan is the annual adjustment to the price cap. An annual price cap adjustment consists of three components.

1. a productivity offset (X) which is stable over a long period of time,

2. the annual change in U.S. output prices as measured each year by the GNP fixed weight price index (GNP-PI), and

3. the annual change in costs (Z) due to exogenous events such as regulatory separations or accounting changes.

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[4]For example, one expects improvements in demand and market-related areas (customer relations, marketing, development of new services, etc.) under price cap regulation, since expansion of demand contributes to earnings in the same way as reductions in costs. As a source of productivity change, such improvements are likely to be slower in arriving than the productivity changes from cost reductions which have sustained productivity growth in the telecommunications industry in the past.

[5]This presumes the absence of an earnings sharing mechanism. An earnings sharing mechanism hinders the achievement of technical efficiency.

The logic of the price cap adjustment formula is to select the appropriate productivity offset such that the allowed price changes reflect efficient behavior. The formula for the price cap adjustment can be derived from the relationship among changes in output prices, changes in input prices, and the rate of growth of total factor productivity (TFP) for the firm.

Using that formula and data over some historical period, there are two methods of determining a productivity offset X:

(i) a direct method, which calculates the historical rate of TFP growth of the LEC industry from the difference between the growth rates of physical outputs (lines, minutes, etc.) and physical inputs (labor, capital, raw materials) and subtracts the historical rate of TFP growth for the economy as a whole, and

(ii) an indirect method, which measures the rate of change of output prices for the LEC industry relative to those of the economy as a whole.

The economic principle of duality can be used to show the theoretical equivalence of these two approaches to productivity measurement under certain conditions.

In an accompanying submission in this docket, Christensen Associates perform the direct calculation of LEC industry TFP growth for the 1984-1992 period. The direct approach to the calculation of an offset has two advantages over the indirect approach reported by the Commission at the inception of LEC price cap regulation. First, this measure of a productivity offset uses a measure of capital input based on economic asset lives rather than the implicit regulatory accounting asset lives that are embedded in the prices used in the indirect method of calculating the productivity offset. Economic lives

are presumed to be a more accurate measure of how long capital is useful than the accounting lives which were assigned to accommodate policy goals such as service affordability. Secondly, the direct measure of TFP growth uses lines and minutes as measures of output growth, so that no separate measure of growth in minutes of use per line ("g" in the Balanced 50/50 formula using the indirect method) is necessary to calculate the productivity offset using the direct method.

B. Output Price Changes for the Industry

A basic identity in economic theory states that--for an individual firm or industry--the rate of growth of TFP is equal to the difference between the rates of growth of the firm's input prices and output prices.[6] Applying this rule to the LEC yields

(1) $$dp = dw - dTFP \pm dZ$$

where dp represents the annual percentage change in output prices, dZ represents the unit change in costs due to external circumstances,[7] and dw represents the annual percentage change in input prices. Thus revenue changes for a price cap regulated firm would tend towards efficiency when the price cap formula (i) increases the firm's output prices at the same rate as its input prices less the offset change in productivity growth, and (ii) directly passes through exogenous cost changes.

Equation (1) looks a great deal like the annual adjustment equation in the LEC price cap plan: the allowed price change for the industry is set at a measure of its input

[6]This rule is derived in Appendix I by differentiating the identity that total revenue equals total cost.

[7]Note that Z^* can be positive or negative.

price change less its TFP growth adjusted for exogenous cost pass-throughs. If GNP-PI were taken as a measure of the LECs' input price growth and X were the its TFP growth, equation (1) would indeed be the same as the LEC price adjustment formula. However, there are three errors in this interpretation. First, if equation (1) applied uniquely to the regulated firm, price cap regulation would not differ materially from traditional RoR regulation. If input prices, productivity growth and exogenous cost changes were updated each year, the output price change that would result in each year would mirror the change in costs, in just the same way as under RoR regulation. Second, GNP-PI measures national output price growth, not the firm or the LEC industry's input price growth, so even if the firm or the industry is a microcosm of U.S. industry, GNP-PI is not an appropriate measure of its input price growth.[8] Third, X in the LEC plan is a differential TFP growth rate for regulated firms relative to U.S. industry as a whole (or relative to the TFP growth already embodied in the GNP-PI). The change in TFP in equation (1) is the absolute TFP growth for the LEC industry. Again, unless U.S. TFP growth is zero, X is not equal to *dTFP*.

To get from equation (1) to the LEC price adjustment formula, we must compare the productivity growth of the LEC industry with the productivity growth of the U.S. economy.

[8]Recall that input price growth differs from output price growth by the growth in TFP. Hence, only when national productivity growth is zero does GNP-PI growth equals national input price growth.

C. Output Price Changes for the Economy

For the U.S. economy as a whole, the relationship among input prices, output prices, productivity, and exogenous cost changes can be derived in the same manner as it was derived in equation (1) above, differentiating the identity that the value of output is equal to the expenditure on inputs.

$$dp^N = dw^N - dTFP^N \pm dZ^N \tag{2}$$

where dp^N is the annual percentage change in a national index of output prices; dw^N is the annual percentage change in a national index of input prices; $dTFP^N$ is the annual change in the economy-wide total factor productivity and dZ represents the change in national output prices caused by the exogenous factors included in equation (1). If we subtract equation (2) from equation (1), we see that

$$dp - dp^N = [dw - dw^N] - [dTFP - dTFP^N] \pm [dZ - dZ^N],$$

or

$$dp = dp^N - [\,(dTFP - dTFP^N) - (dw - dw^N)\,] \pm [\,dZ - dZ^N\,],$$

which simplifies to

$$dp = dp^N - X \pm Z. \tag{3}$$

Equation (3) is the theoretical equivalent of the LEC price adjustment formula. The allowed price change for the regulated firm for a particular year is given by:

1. the rate of inflation of national output prices dp^N measured by the GNP-PI,
2. less a productivity offset, X, which now represents a productivity growth differential between the annual TFP growth of the regulated industry and the

U.S. economy, adjusted for differences, if any, between the rate of growth of input prices for the regulated industry and the U.S. as a whole.[9]

3. plus exogenous unit cost changes, written as the difference in the unit costs of the exogenous change between the regulated industry and the U.S. economy.

Simple algebra translates equation (3) into the formula that appears in the LEC price cap plan:

$$(4) \qquad P_t = P_{t-1} \times [\ 1 + GNP\text{-}PI_{t-1} - X\ ] + Z_{t-1}$$

where P_t represents the regulated firm's weighted average price using base period quantities. As written, the price cap formula adjusts prices in each period for inflation and exogenous cost changes but leaves the productivity offset held constant during the plan.

Equation (4) is the foundation of the price adjustment formula in the LEC price cap plan. In words, the allowed change in output price for an individual firm is equal to (i) the change in a national index of output prices less (ii) the productivity offset, measured as the difference between the change in LEC TFP and that of the nation as a whole, plus (iii) the difference between the effect of exogenous changes on LEC costs and on the costs of the nation as a whole. National output prices (GNP-PI) and exogenous changes (Z) are measured annually, but the productivity offset (X) is set for a longer period of time.

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[9] This differential is equal to the difference between the firm and U.S. TFP growth rates if the rates of input price growth are the same for the firm and the nation: i.e., if $dw = dw^N$. Evidence supporting this assumption was presented by Dr. Laurits Christensen in Appendix F of AT&T's Comments in response to the FCC's Notice of Proposed Rulemaking in CC Docket 87-313, filed October 19, 1987. According to Dr. Christensen's calculations, input cost inflation for the Bell System and for the total U.S. private domestic economy averaged 4.5% and 4.6% respectively for the years 1948 through 1979. A more recent examination of this assumption is undertaken in Section II.B.

The incentive structure of the price cap plan in equation (3) is quite different from that in equation (1). If equation (1) were the basis of a price cap plan, the regulated firm would find its output prices increasing faster than its input prices only if its productivity growth exceeded that of the LEC industry, embodied in the productivity offset X.[10] If equation (3) were the foundation of the price cap plan, the regulated firm would find its output prices increasing faster than its input prices only if its productivity growth exceeded national productivity growth by more than the historical amount by which LEC industry productivity growth exceeded national productivity growth. In equation (1), the regulated firm effectively competes against a standard set by the LEC industry; if LEC industry TFP growth increased rapidly, the individual firm would have to meet and exceed that productivity growth rate in order for earnings to improve under equation (1). In equation (3), the firm also competes against all other firms in the U.S. economy; if U.S. TFP growth were to increase, the firm would have to match that productivity growth in order to match the historical differential between LEC industry TFP growth and national TFP growth.

If equation (1) were used in a price cap formula, the input price growth rate of the regulated industry would have to be measured, and the industry would be permitted to pass through changes in those input prices through its output prices. Since no outside agency routinely calculates LEC input price indices and since automatic pass-through of input price changes for the industry would diminish its incentives to control those price changes (e.g., through collective bargaining), a price cap plan based on equation (1) would

[10]Assuming input price growth rates to be the same for the firm and the LEC industry.

be difficult to implement and would attenuate somewhat the incentive improvement expected from price regulation. For those reasons, the differential formula (3) is used frequently and equation (1) is never used.

This theoretical background enables us to understand the function of each element of the LEC price cap plan. We can now assess how well each component has performed since 1990.

II. INFLATION

Inflation in the annual price cap adjustment formula plays a very specific role, and a role that has confused a number of parties in state and federal price cap proceedings. The confusion stems from mistaking equation (3) for equation (1) above. That is, it is sometimes thought that the role of the change in GNP-PI in the price cap formula is to measure changes in input prices, as denoted by dw in equation (1). On the contrary, as our above derivation shows, the role that GNP-PI plays in the price cap formula is to measure output price changes for the U.S. economy as a whole. More specifically, because the productivity offset is expressed as the differential between the LEC industry rate of growth of TFP and that of the U.S. economy, the measure of output price growth in the formula pertains to the specific entity whose TFP growth we have used in calculating the productivity differential.

The measure of national output price changes, combined with the productivity differential, accounts for changes in input prices affecting the LECs. It performs this

function by measuring the output price change corresponding to the sector of the economy against which LEC TFP growth is compared in the productivity offset. How have national output prices changed over time?

There are two commonly used measures of output price growth for the U.S. as a whole that could be used in the price cap adjustment formula:

- The GNP-PI measures the price change for the aggregate of the components of Gross National Product (GNP). At the initialization of LEC price caps, the GNP-PI was calculated using 1982 commodity weights. The same index was used in the 1991 annual filling. The index has since been reweighted and since 1992, filings have used an index with 1987 weights.[11]

- The GDP-PI measures price changes for the aggregate of the components of Gross Domestic Product (GDP) using 1987 commodity weights.

Both indices measure output price growth but for slightly different bundles of outputs. Gross National Product is the value of final goods (as opposed to intermediate goods) produced by U.S.-owned factors of production. Gross Domestic Product is about 99 percent of Gross National Product, omitting that portion of the output of final goods and services produced abroad by all U.S.-owned factors of production and including that portion of the output of final goods and services produced in the U.S. by foreign-owned factors of production.

[11]The two GNP-PIs use different weights to represent the relative importance of the different components of the GNP.

A. National Output Price Changes

Since 1982, the levels of GNP-PI, and GDP-PI have been virtually the same. These measures of national inflation have grown at average annual rates of 3.65 and 3.66 percent respectively.[12] Since 1990, during the price cap period, the two measures have averaged 3.50 and 3.51 percent growth respectively. Differences between the 1987-weighted GNP-PI and GDP-PI measures are negligible during the 1990-1993 period.

Currently, when applying the adjustment formula LECs are instructed to use the forty-five day preliminary GDP-PI numbers and then perform a true-up with a seventy-five day GNP-PI. To the extent that this is an administrative burden, we see clear advantages from allowing the LECs to use the GDP-PI throughout. The numerical differences are negligible, and in fact, there is a theoretical benefit from using the GDP-PI. The GDP-PI is somewhat more likely to measure output price changes for the bundle of goods and services whose TFP growth is measured by the BLS.[13]

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[12]Calculated by averaging annual rates of growth.

[13]The BLS produces aggregate TFP growth calculations for U.S. private business, non-farm business, and manufacturing. U.S. private business accounts for about 80 percent of GNP; it excludes the government sector, owner-occupied housing, nonprofit institutions, private household employees, and the rest-of-the-world (ROTW) account. Thus, the set of goods and services measured by the GDP-PI is somewhat closer to the set of goods and services produced by U.S. private business because both GDP and U.S. private business exclude the ROTW sector. As a practical matter, however, the LECs' current 3.3 percent productivity offset was not determined in the previous proceeding by subtracting a TFP growth rate for the LECs from a TFP growth rate for U.S. private business as calculated by the BLS. Nonetheless, the U.S. TFP data compiled by the BLS are commonly used, and most parties' perception of a reasonable productivity offset for the LECs is determined, at least in part, by those results. In practice, this adjustment is negligible for a shift to the GDP-PI because the growth rates of the GNP-PI and GDP-PI are so similar.

B. Input Price Changes

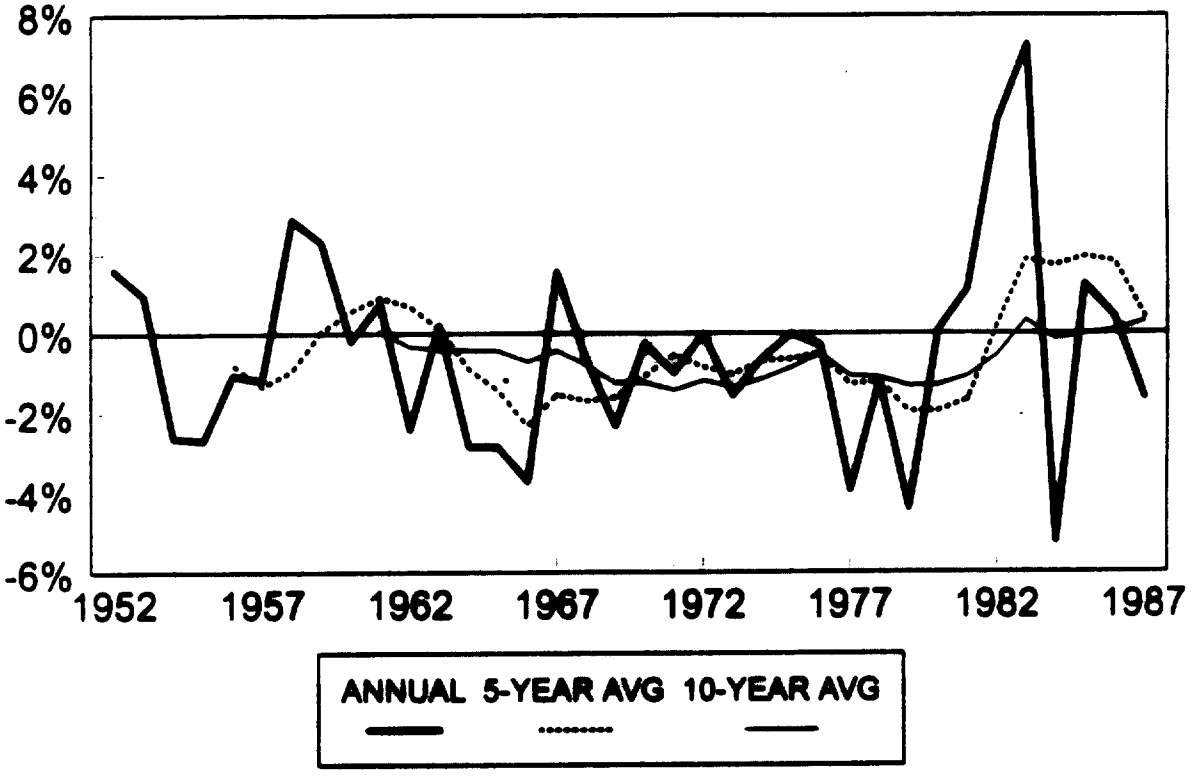
Central to the interpretation of the productivity offset in the price cap formula is the assumption that input price growth for the U.S. economy is the same as that for the LEC industry. If these input price growth rates differ, that difference is included as part of the productivity offset, as can be seen in equation (3).[14] To shed some light on the relationship between telecommunications input price growth and national input price growth, we compared the input price index for the U.S. telecommunications industry and the U.S. Private Business Sector for two different analysis periods: 1951-1987 and 1984-1990. Each analysis period corresponds to available data.

For the first period, 1951-1987, we rely upon a TFP study conducted by L.R. Christensen. Using the Bureau of Labor Statistics (BLS) multifactor productivity growth estimates for U.S. Private Business and the GNP-PI measure of national output price changes, we calculated an input price index for the U.S. economy for the years 1951-1987. While in any year, this estimate of input price growth differs between the telecommunications industry and the U.S. economy, those differences largely balance out over time. If we calculate a ten-year moving average annual growth rate for both, the largest difference between the two is 1.4 percentage points over the 1961-1987 period. In a given year, the difference in input price growths can be as little as 0.01% or as much as 7.2%. Figure 1 shows that over the long run, however, input price growth for the U.S. approximates telecommunications input cost inflation. As of 1987, long-run

[14]When the indirect method of measuring the historical productivity offset is used--as the Commission did in 1990--the measured value of X includes both the productivity differential and the difference--if any--in input prices.

annual input price growth averaged 6.53% for the industry and 6.23% for the U.S, differing by only 0.30%. Moreover, there was no statistically significant difference between industry and U.S. input price growth.

Figure 1
Annual Input Price Growth Rate Differences
Telecommunications - U.S. Economy
1951-1987



Our analysis of input price growth differences over the shorter, more recent period (1984-1990) yields similar results.[15] Using the recent industry TFP study of L. R. Christensen, BLS multifactor productivity growth estimates for U.S. Private Business, and the GNP-PI measure of national output price changes, we again calculated an input price

[15]While the recent Christensen study reports results from 1984 to 1992, BLS multifactor productivity results are only available through 1990.

index for the U.S. economy. Between 1984 and 1990 input price growth for the U.S. ranged from 3.5 to 6.3 percent while input price growth for the industry ranged from -0.4 to 12.0 percent. For this period of analysis we again find that there was no statistically significant difference between industry and U.S. input price growth. From this exercise, we conclude that the productivity offset in a price cap plan should be the simple differential between the annual TFP growth of the regulated firm and the U.S. economy; there is no reliable evidence that input prices have grown--or will grow--at different rates for the telecommunications industry and the U.S. as a whole.[16]

III. PRODUCTIVITY GROWTH

Technical efficiency in economics has two components. Static efficiency asks whether at any point in time, the firm has produced as much output as possible given the inputs it has used or, equivalently, whether the firm has produced its given level of output using the lowest-cost bundle of inputs. Dynamic efficiency asks whether the firm invests wisely in cost-reducing or demand-expanding technological progress to increase the maximum output possible given its inputs or to reduce the minimum cost of producing a given level of output. If price cap regulation is to provide future ratepayers with efficient telephone service, it is essential that dynamic efficiency be a major design criterion and that incentives be established so that actual LEC productivity growth is as high as

[16]Indeed, as shown below, direct measurements of the productivity differential are generally consistent with the indirect measurements based on prices. Since the indirect measurement includes the difference in input price growth rates and the direct measurement does not, the fact that the two methods produce similar results implies that the difference in input price growth rates is small over reasonably long periods of time.

possible.[17] To achieve this goal, modifications--if any--to the price cap plan should be examined in light of their possible consequences on the rate and direction of capital investment in the network.

A. Productivity Concepts

Productivity growth is an increase in the amount of output obtainable from a given set of inputs. There are a number of ways of measuring both outputs and inputs which give rise to different measures of productivity growth. While each measure has its use, the only comprehensive measure is total factor productivity (TFP).

Total (or multi) factor productivity measures the change in aggregate output corresponding to a given change in all inputs. In most calculations, aggregate output growth is measured by a revenue-weighted average of the growth rates of individual outputs, and aggregate input growth is measured by an expenditure-weighted average of the growth rates of individual inputs.[18]

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[17]Establishing incentives to elicit rapid productivity growth is completely different from setting a high productivity offset. The Commission deliberately chose to set a productivity offset above the historical rate of productivity growth of the industry presumably to induce a higher growth in TFP. However, the principle feature of price caps that improves a firm's incentives to become more productive is that the productivity offset is unaffected by the firm's performance. Whether that offset is low or high does have other important effects on stockholders, on ratepayers, and on the incentives of the firm to invest in its business. If the price cap plan were modified to reduce the productivity offset, for example, investment in the regulated telephone network would become more attractive, stimulating capital investment in domestic telecommunications that might otherwise be deployed elsewhere.

[18]In contrast, single factor productivity--most often labor productivity--measures the change in aggregate output corresponding to a given change in a single input, e.g., change in output per worker. While there are some legitimate uses for labor productivity measures, labor productivity cannot be used to measure the change in the productive capacity of the firm.

1. Total (Not Partial) Factor Productivity is Implied by the Price Cap Formula

For use in the price cap formula, total factor productivity (TFP) is the only appropriate measure of productivity growth. First, use of TFP in setting a productivity offset avoids distortions in the incentives of the firm. If, for example, prices of the regulated firm were tied somehow to attainment of a labor productivity objective, the firm would have the incentive to hire labor until the point at which the average productivity of labor was maximized. This input choice rule is inconsistent with the rule followed by profit-seeking firms in unregulated markets: to hire labor until the value of the additional product made possible by the last worker just equals the wage rate.

Second, given the structure of the annual price cap adjustment formula, only total factor productivity can be used to set the productivity offset. The annual price cap adjustment formula is designed so that if the firm achieves the industry productivity goal, the allowed growth in its price cap will just equal the realized growth in industry input prices. In Appendix I we demonstrate that TFP is the appropriate foundation for a productivity offset in the price cap plan.

B. Possible Changes in the Productivity Offset

A purpose of this review of the LEC price cap plan is to determine how the LEC price cap plan should be improved if experience suggests that parameters of the plan were set incorrectly or that circumstances had changed. In this section, we examine some issues regarding the productivity parameter of the plan: an analysis of the frequency with which the productivity offset should be updated, and an assessment of different productivity comparisons implicit in the productivity offset. We conclude that if any change is

warranted, the productivity offset should be lower than the current 3.3 percent, a result that confirms the findings reported in the Christensen Associates' study in this filing.

1. Should the Productivity Offset be Updated More Frequently?

To update the productivity offset routinely as part of the price cap plan would mitigate the very improvements in incentives that the Commission set out to create.[19] Under the current plan, the LECs' productivity offset was set at the beginning of the price cap period and is now being reviewed after three years. This arrangement differs from the inflation adjustment component of the price cap adjustment formula which is calculated anew in each annual price cap filing, based on the most recent reliable inflation data obtainable. From past evidence of the volatility of TFP growth over short periods of time, we conclude that use of short-term productivity results to make frequent productivity offset updates (i.e., every four years) would damage the workings of a price cap regulation plan.[20]

True productivity growth for a firm, an industry, or the U.S. as a whole varies a great deal from year to year because of productivity-increasing or productivity-decreasing activities that occur less frequently than once per year. For example, suppose every five years, a firm undergoes a significant restructuring in which workers and managers identified as surplus are eliminated from the payroll. Measured productivity growth from

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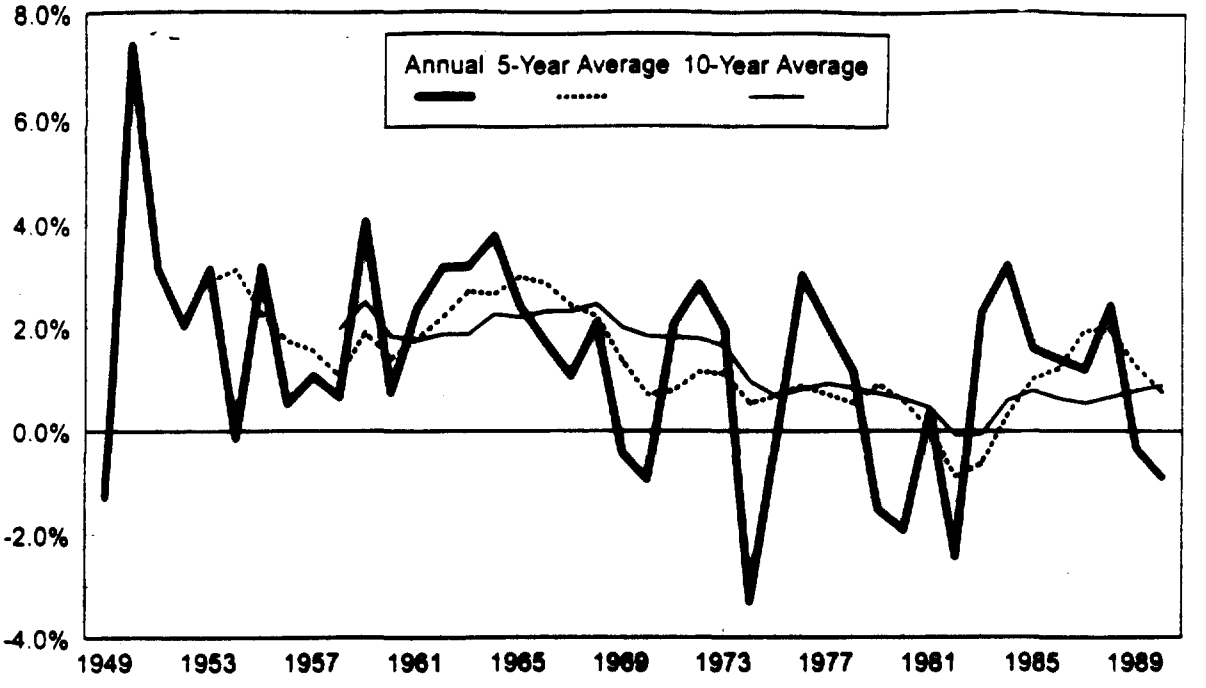
[19]Similarly, the adoption of a mechanism to adjust prices to reflect changes in interest rates would also diminish the incentive improvements of price caps relative to current RoR regulation.

[20]Volatility aside, if an individual LEC's own productivity growth were used to establish a productivity adjustment for that LEC, the incentive basis of the price cap formula would degenerate. A plan in which a LEC's TFP growth this year determined its price growth next year would be perilously close to ordinary RoR regulation.

Figure 2
U.S. Private Business TFP Growth



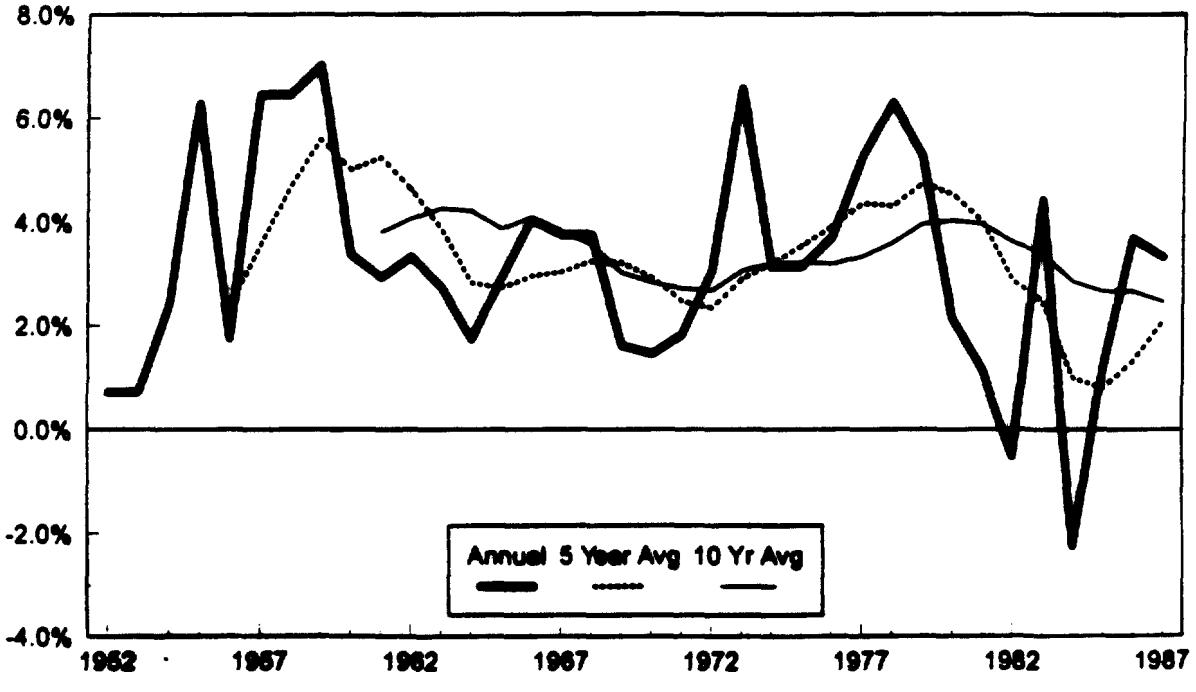
this source would show (i) no change in four years out of five and (i) a productivity increase in the fifth year that was roughly five times its long run annual rate. Obviously if this source of productivity growth were important, productivity measurement averaged over less than a five year period would yield a serious bias. In Figure 2, annual growth in U.S. TFP is shown, and it is clear that growth estimates from one or two years can seriously misstate the long run average TFP growth at any point in time. Using J. Kendrick's estimates of U.S. TFP growth from 1884 to 1969, the picture that emerges is that the volatility of TFP growth exceeds that of the U.S. business cycle, and that the average frequency of the TFP growth cycle over this period is about 3 years.[21] More recent analysis by the U.S. Department of Commerce, suggests that between 1945 and

[21]Thus annual growth in TFP rises and falls more rapidly than annual growth in GNP, averaging about 3 years between peaks or between troughs. J.W. Kendrick, Long Term Economic Growth 1860-1970, Washington D.C.: U.S. Bureau of the Census, June 1973.

1990 the business cycle length has increased to 5 years.[22] For statistical purposes then, a minimum 3 year and perhaps even a 5 year period (a complete cycle) should be treated as a single observation. Multiple 3 or 5 year periods--i.e., a minimum of 6 and maybe as many as 10 years--must be observed to calculate a meaningful average productivity measure with any degree of precision.

The volatility of annual TFP measures is greater for smaller aggregates, such as firms or industries. Figure 3 shows annual TFP growth for the telecommunications

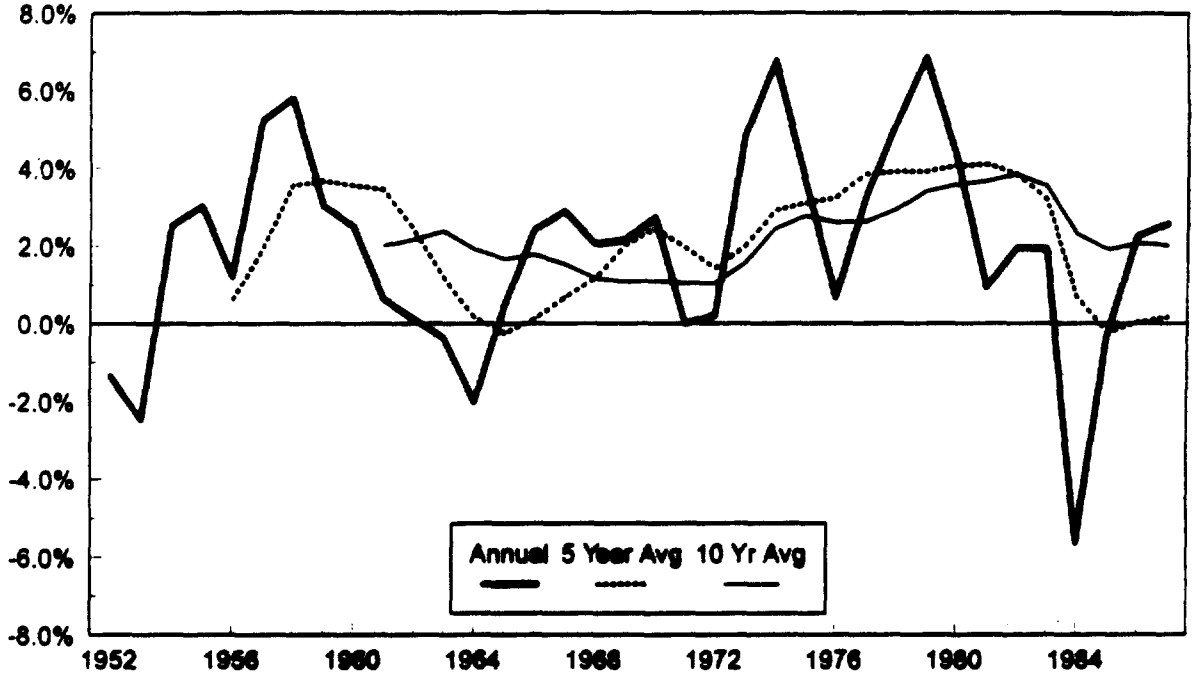
Figure 3
Telecommunications Industry TFP Growth



[22]U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business*, April 1992, C-25.

industry, as calculated by L.R. Christensen in his 1951-1987 study.[23] Comparison with Figure 2 shows significantly greater volatility at the industry level than for the U.S. as a whole. Finally, it is only the difference between national and firm TFP growth that matters for the productivity offset in the price cap formula. Figure 4 shows considerable variation in annual productivity differences, ranging from 6.8 to -5.6 percent per year.

Figure 4
Differences in Annual TFP Growth
Telecommunications - U.S. Private Business



The extreme differences in the ten-year moving average are reduced to a maximum of +3.8 and a minimum of 1.03 percent.

[23] L.R. Christensen, op. cit.

The picture in Figure 4 also shows clearly that the long-run productivity differential between the U.S. telephone industry and U.S. private business averages about 2 percent per year. This same 2 percent differential has been observed by most students of telecommunications productivity; possibly its strongest statement was provided by the FCC staff in the federal price cap docket where they noted a constant productivity differential (using output prices) of between 1.7 and 2 percent over the 1930-1989 period.[24] This relationship suggests that the 3.3 percent productivity differential chosen by the Commission, viewed from a long-run historical perspective, was an ambitious goal to set that would require higher than historical rates of productivity growth to accomplish.

These results show that annual productivity growth is too volatile to be used as a determinate of annual updates to the productivity offset. To obtain the full benefit of incentives to increase productivity growth and achieve the highest possible dynamic efficiency, the productivity offset must be stable over a long period of time, so that the firm will treat it as independent of any of its actions. As we discussed earlier, this gain in dynamic efficiency is purchased at the cost of a deterioration in allocative efficiency, if the firm's prices are permitted to deviate much from its costs.[25]

The risk of updating the productivity offset is that it encourages the firm to treat the offset as subject to its control or--at least--subject to uncertainty. This danger

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[24]Supplemental Notice of Proposed Rulemaking, CC Docket 87-313, (released March 12, 1990), Appendix D, "Total Telephone Productivity in the Pre and Post Divestiture Periods," by T.C. Spavins and J.M. Lande, and Second Report and Order, CC Docket 87-313, (released October 4, 1990), Appendix D, "The Long Term View of the Appropriate Productivity Factor for Interstate Exchange Access," by T.C. Spavins.

[25]An illuminating theoretical study of this tradeoff is contained in R. Schmalensee, "Good Regulatory Regimes," The Rand Journal of Economics, Autumn 1989, pp. 417-436.